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PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

MISSOURI HEADWATERS BASIN
TUB LAKE DAM
BEAVERHEAD COUNTY, MONTANA
MT-822

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PREPARED FOR

HONORABLE TED SCHWINDEN
GOVERNOR, STATE OF MONTANA

BEAVERHEAD WATER COMPANY
(OWNER/OPERATOR)

PREPARED BY:
HOSKINS-WESTERN-SONDEREGGER, INC.

APRIL, 1981

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EXECUTIVE SUMMARY

Under contract with the Seattle District Corps of Engineers and with representation from the Owner and the State of Montana Department of Natural Resources and Conservation, Tub Lake Dam was inspected by Hoskins-Western-Sonderegger, Inc., on 20 September 1979, under the authority of Public Law 92-367. Tub Lake Dam is located in Beaverhead County, Montana, approximately 22 miles northwest of Dillon.

This report was compiled from information obtained furing an on-site inspection, a review of operation records, and an analysis of hydrologic and hydraulic data. Findings were compared to engineering criteria currently accepted by most private and public agencies engaged in dam design, construction, and operation.

PRINCIPAL FINDINGS AND EVALUATIONS

Tub Lake Dam is one of four dams in the Birch Creek watershed, owned and operated by the Beaverhead Water Company, which are used for irrigation storage. The other dams are Anchor Lake Dam, Pear Lake Dam, and Boot Lake Dam, the latter two of which are downstream from Tub Lake Dam. The Tub Lake project consists of a natural lake and an embankment to raise the lake elevation for irrigation storage. The reservoir has a drainage area of 0.25 square miles, a surface area of about 15 acres at normal pool, and storage at dam crest of 208 acre-feet. At the time of inspection, the reservoir was drained to its natural level. The project is operated under a Department of Interior easement which was filed under the Public Lands Act of March 3, 1891.

For many years the low-level outlet control works have been inoperative, with the control valve at least partially open. Therefore, the pool has been at the natural lake level, except for temporary flood storage whenever reservoir inflow exceeded the conduit capacity. Extensive rehabilitation will be necessary if water is ever again to be stored for irrigation purposes.

In accordance with the "Recommended Guidelines for Safety Inspection of Dams" (Ref. 1), the 11.5-foot-high Tub Lake Dam (MT-822) is classified as being of small size and as having a significant (Category 2) downstream hazard potential, due to the presence of approximately 2 inhabitable structures located approximately 10 miles downstream of Boot Lake, along Birch Creek.

Inspection criteria (Ref. 1) recommend that a small-sized project with a significant downstream hazard potential be capable of safely handling a spillway design flood (SDF) in the range of the 100-year flood to one-half of the probable maximum flood (PMF). The PMF is the flood expected from the most severe combination of meteorologic and hydrologic conditions that are reasonably possible in the region. Since Pear Lake Dam and Boot Lake Dam are both located downstream of Tub Lake Dam, and Boot Lake Dam is

classified as intermediate size and is, thereby, required to handle at least one-half of the PMF, we recommend that Tub Lake Dam also handle one-half of the PMF.

During the dam dafety analysis, an estimated PMF was developed for the drainage basin, resulting from a 24-hour storm. The resulting PMF has an estimated volume of approximately 200 acre-feet. The reservoir level at the beginning of the 24-hour storm was assumed to be at the spillway crest elevation. Infiltration losses were assumed to be zero. Reservoir routings of the estimated 24-hour PMF indicate that the project will handle about 28% of the PMF volume before overtopping. The dam is constructed of materials that would probably erode and fail when overtopped by flood-waters. Discharges from a dam failure were included in the inflow hydrographs to the downstream Pear and Boot Lake Dams.

On the basis of the field inspection and the study of hydrologic and operational data, Tub Lake Dam does not conform to Corps guidelines with respect to discharge and/or storage capacity to safely handle the re-commended SDF.

Evidence of foundation or abutment seepage was found at the downstream toe and in the abutment troughs. Seepage under full pool conditions could lead to embankment failure by piping. No piezometers are installed to measure water levels in the embankment, and there is no known internal drainage system. Forest Service inspection reports indicate a history of maintenance problems dating back to at least 1961. Conditions describ-ed in this report suggest that the dam does not conform to the recommended guidelines (Ref. 1) with respect to the stability of the downstream em-bankment slope.

PRINCIPAL RECOMMENDATIONS

If the project is no longer needed for its intended purpose, safely remove the dam to prevent impounding hazardous volumes of water. If the project is to be restored, it should conform to inspection guidelines as recommen-ed hereafter.

A downstream notification plan, for use in the event of possible embankment failure, needs to be developed and placed into operation immediately. The conduit inlet must be uncovered, and a suitable inlet structure constructed. The outlet control works need to be replaced or extensively repaired. A formal maintenance program needs to be established and followed.

A discussion of all of the many alternatives which exist for failure or overtopping of the dams and reservoirs in this watershed and the responses to these failures or overtoppings by downstream dams and reservoirs is very complex and beyond the scope of this preliminary study. It is re-commended that additional, more-detailed studies be initiated on this watershed so that a better understanding of the complex situation is achieved. Modify the project as the studies indicate.

Analyses should be performed by a qualified geotechnical engineer, experienced in dam design and construction, to determine if embankment modifications are required to provide adequate stability. Modify the project as studies indicate.

Prior to performing engineering studies and/or remedial construction, coordinate all work with the U.S. Forest Service and the State of Montana Department of Natural Resources and Conservation to insure compliance with all pertinent laws and regulations.

Stephen H. Nickel
Professional Engineer

PERTINENT DATA

1. GENERAL

Federal Identification Number	MT-822
Owner	Beaverhead Water Company
Operator	Beaverhead Water Company
Purpose	Irrigation
Location	Sections 4 & 5, T5S, R11W Beaverhead County, Montana
Watershed	Birch Creek
Downstream Hazard Potential	Significant
USGS Quadrangle	Torrey Mountain, Montana Polaris, Montana

2. RESERVOIR

Surface Area at Normal Pool (Spillway Crest)	15 acres
Normal Storage (Spillway Crest)	172 acre-feet
Total Storage (Minimum Dam Crest)	208 acre-feet
Surcharge Storage	36 acre-feet
Drainage Area	0.25 square miles
Reservoir Water Surface Elev. (9/20/79)	9079.0 feet (NGVD)- natural pool elevation

3. SPILLWAY

Type	Uncontrolled earth and rock channel
Crest Elevation	9087.4 feet (NGVD)
Crest Width	4 feet
Spillway Capacity (Minimum Dam Crest)	55 cfs

4. OUTLET WORKS

Type	Controlled steel pipe
Controls	Gate valve with manual control from dam crest
Size	18-inch diameter
Length	45 feet
Inlet Invert	Unknown
Outlet Invert	9078.1 feet (NGVD)
Normal Tailwater	Unknown
Discharge Capacity (Minimum Dam Crest)	27 cfs

5. DAM

Type	Earth and rockfill
Maximum Height (Hydraulic Height)	11.5 feet
Crest Length	180 feet
Minimum Crest Elevation	9089.6 feet (NGVD)
Crest Width	17 feet
Upstream Slope	1(V) on 2(H)
Downstream Slope	Vertical rock wall

CHAPTER 1

BACKGROUND

1.1 INTRODUCTION

1.1.1 Authority and Scope

This report summarizes the Phase I inspection and evaluation of Tub Lake Dam, owned and operated by the Beaverhead Water Company of Dillon, Montana.

The National Dam Inspection Act, Public Law 92-367 dated 8 August 1972, authorized the Secretary of the Army, through the Corps of Engineers, to conduct safety inspections of non-federal dams throughout the United States. Pursuant to that authority, the Office of the Chief of Engineers issued "Recommended Guidelines for Safety Inspection of Dams" (Ref. 1) in May 1975.

The recommended guidelines were prepared with the help of engineers and scientists, highly experienced in dam safety, from many federal and state agencies, professional engineering organizations and private engineering consulting firms. Consequently, the evaluation criteria presented in the guidelines represent the comprehensive consensus of the engineering community.

Where necessary the guidelines outline a two-phased study procedure for investigating and evaluating existing dam conditions so deficiencies and hazardous conditions can be readily identified and corrected. The Phase I study is:

(1) a limited investigation to assess the general safety condition of the dam;
(2) based upon an evaluation of the available data and a visual inspection;
(3) performed to determine if any needed emergency measures and/or if additional studies, investigations and analyses are necessary or warranted; and
(4) not intended to include extensive explorations or analyses or to provide detailed alternative correction recommendations.

The Phase II investigation includes all additional studies necessary to evaluate the safety of the dam. Included in Phase II, as required, should be additional visual inspections, measurements, foundation exploration and testing, materials testing, hydraulic and hydrologic analyses and structural stability analyses.

The authority for the Corps of Engineers to participate in the inspection of non-federally owned dams is limited to Phase I investigations with the exception of situations of extreme emergency. In these cases the Corps may proceed with Phase II studies but only to the extent needed to answer serious questions relating to dam safety that cannot be answered otherwise. The two phases of investigations outlined above are intended only to evaluate

project safety and do not encompass in scope the engineering required to perform design or corrective modification work. Recommendations contained in this report may be for either Phase II safety analyses or detailed design study for corrective work.

The responsibility for implementation of these Phase I recommendations rests with the dam owner and the State of Montana. It should be noted that nothing contained in the National Dam Inspection Act, and neither action nor failure to act under this Act shall be construed (1) to create liability in the United States or its officers or employees for the recovery of damage caused by such action or failure to act or (2) to relieve an owner or operator of a dam of the legal duties, obligations, or liabilities incident to the ownership or operation of the dam.

1.1.2 Purpose

The purpose of the inspection and evaluation is to identify conditions that threaten public safety, so that they may be corrected in a timely manner by non-Federal interests.

1.1.3 Inspection

The findings and recommendations in this report were based on visual inspection of the project and an interview with the owners. Records of U.S.F.S. inspections, dating as far back as 1959, were furnished for reference. No design drawings or foundation exploration results were available for review or analysis. Inspection procedures and criteria were those established by the "Recommended Guidelines for Safety Inspection of Dams" (Ref. 1).

Personnel present during the inspection included:

Louis Boitano, Civil Engineer, Seattle District Corps of Engineers;
Art Taylor, Civil Engineer, State of Montana, Department of Natural Resources and Conservation; and
Garth Taylor, President, Beaverhead Water Company.

Hoskins-Western-Sonderegger, Inc. (HWS) personnel who participated in the field inspection and contributed to this report are:

Stephen Nickel, Geotechnical Engineer, Team Leader;
Mike McMeekin, Hydrologist/Hydraulics Engineer; and
Gene Holtorf, Hydrologist/Hydraulics Engineer.

This report has been reviewed by representatives of the Beaverhead Water Company, the U.S. Forest Service, the Bureau of Land Management, and the Montana Department of Natural Resources and Conservation. Their written comments have been included in the Appendix of this report.

1.2 DESCRIPTION OF PROJECT

1.2.1 General

Tub Lake is one of four high mountain lakes owned and operated by the Beaverhead Water Company, which are used to store snowmelt and runoff for irrigation. It is operated under a Department of Interior easement which was filed under the Public Lands Act of March 3, 1891. Anchor Lake (drainage area = 0.46 square miles) and Tub Lake (drainage area = 0.25 square miles) drain into Pear Lake (local drainage area = 0.76 square miles), which drains into Boot Lake (local drainage area = 1.53 square miles). The total area of the watershed is approximately 3.0 square miles. Tub Lake is located in Sections 4 and 5, Township 5 South, Range 11 West, Beaverhead County, Montana, approximately 22 miles northwest of Dillon, Montana, on Birch Creek.

Tub Lake's natural storage capacity of about 27 acre-feet was increased to a total capacity of approximately 208 acre-feet with the construction of Tub Lake Dam (MT-822) and 2 small dikes in 1904. A 4-foot-wide, uncontrolled spillway for the facility is located at the left abutment of the dam. The dam has an 18-inch-diameter steel pipe low-level outlet, which formerly was used to control the amount of discharge from the lake during the irrigation season but is now inoperable. Tub Lake Dam is 11.5 feet high and impounds 208 acre-feet of water at the minimum crest elevation of 9089.6 feet. Based on a visual reconnaissance and engineering judgment, approximately 2 inhabitable structures located approximately 10 miles downstream of Boot Lake along Birch Creek could be affected by a sudden breach of the dam. Tub Lake Dam, therefore, is classified as small in size and as having a significant downstream hazard potential.

1.2.2 Regional Geology

The Pioneer Mountains lie in the southwest corner of Montana. They are bounded by the Anaconda Range to the north, the Beaverhead Mountains in the Bitterroot Range to the west across the Big Hole valley, and the Ruby and Tobacco Root Ranges to the east across the Beaverhead Valley.

The Pioneer Mountains are essentially composed of a complex suite of igneous rocks, the Boulder Batholith, which has intruded into the much older sedimentary and metamorphic rocks of the area. The intrusion of the Boulder Batholith, along with intensive block and thrust faulting, has been the major factor in the geologic structure of the Pioneer Mountains. Present topography is the result of Pleistocene glaciation and valley-fill in the lower intermountain areas.

The northern Rocky Mountain region, prior to Late Cretaceous time, was essentially a flat plain partially flooded by shallow seas. At the end of the Mesozoic Era, of which the Cretaceous is the last geologic epoch, this entire area became geologically active. Three things exemplify this activity: (1) Cretaceous uplift; (2) Late Cretaceous thrust faulting; and (3) Late Cretaceous-Tertiary intrusive activity, i.e., the Boulder Batholith. The regional uplifting of the continental crust brought the earth up in several north-south trending blocks. The west sides of the

faulted blocks, or mountains, are higher in elevation and have characteristically abrupt scarps, while the east sides of the blocks have long, gentle slopes.

The uplifted land became subjected to erosion. As the sediments were transported downslope, they filled the intermountain valleys with debris ranging from muds and sands to gravels and cobbles. These valley-fill sediments attain a depth of several thousand feet in the axis of the mountain valleys.

Pleistocene alpine glaciation of Wisconsin Age (12,000 years before present) sculptured typical alpine glacial features including cirques, headwalls, and troughs in the upper elevations of the Pioneer Mountains. In lower elevations, glacial deposits of terrace gravel, stream bed alluvium, landslide rubble, and glacial drift occur.

1.2.3 Seismicity

Tub Lake Dam (MT-822), located in the Pioneer Mountains, lies in Seismic Zone 3 as indicated by the Seismic Zone Map (Ref. 1). The seismic probability of this regional setting is one of potential for major damage and is based on the known distribution of damaging earthquakes in the region.

The Preliminary Map of Young Faults in the United States, by the U.S. Geological Survey (Ref. 2), indicates suspected activity along the northern expanse of the Pioneer Mountains and Holocene activity directly east, along the northwestern side of the Tobacco Root Range. The Geologic Map of Montana shows extensive faulting prior to the Cenozoic Era in the southern portions of the Pioneer Mountains.

Local earthquakes significant enough to be reported in References 3 and 4 occur in 2 epicentral areas. One of these is to the northeast along a line from 20 miles northwest of Helena to 25 miles north of Bozeman, while the other is to the southeast in northeast Idaho, northwest Wyoming, and the adjoining areas of Montana. Of these two epicentral areas the former is 75 to 100 miles northeast and the latter is 50 to 150 miles southeast of the project site. Two earthquakes of significant intensity that occured in the tri-state region southeast of the project site were the Hebgen Lake, Montana, earthquake (8 August 1959) that had an intensity of X (Modified Mercalli) and another southeast of Dillon, Montana, and southeast of the project area (23 NOvember 1947), that had an intensity of VIII. The three largest reported earthquakes northeast of the Pioneer Mountains have had intensities of VIII. One of these earthquakes had its epicenter at a point 25 miles north of Bozeman (27 June 1925), while the other two occurred at Helena (18 October and 31 October 1935).

In the vicinity of the project there have been numerous other earthquakes in this century (Ref. 3 and 4). In an area bounded by the 44th and 46th parallels and by the 110th and the 112th meridians (including the tri-state region), there have been more than 50 earthquakes with intensities of V and more than 10 with an intensity of VI. The closest reported

earthquakes to the project site have occurred approximately 50 miles east near Ennis and Virginia City, Montana. The largest of these had an intensity of VI and occurred near Ennis (10 March 1977). The exact distance from the epicenter of this earthquake to the project site is not known.

The Pioneer Mountains lie in a highly seismically active area with the potential for a damaging earthquake. This warrants special attention be given to the dams in the area that have been constructed without consideration of the effects of earthquakes.

1.2.4 Site Geology

Tub Lake is a glacial lake. Specifically, it is a small body of water occupying a cirque depression (cirque lake) dammed by a rock lip, small moraine, or both. Very steep cirque headwalls (slopes of 60 to 80%) and strongly scoured glacial trough walls comprise the local terrain. A thin mantle of weathered rock with almost no soil development is typical of the area. Where soil development has begun, the soil is characterized as patchy, very shallow silt loams and sandy loams. Typical mass-wasting features such as talus slopes and rock glaciers, characteristic of very strongly scoured cirque basins, are present. Igenous and metamorphic rocks comprise the local bedrock.

1.2.5 Design and Construction History

According to State of Montana records, Tub Lake Dam was completed in 1904. Construction was supervised by George Metlin, Chief Engineer for Justin E. Morse, Contractor. No additional information on the construction was available. As plans are not available, nothing is known about the placement of material in the dam. The existing low-level outlet pipe appears to have been placed during the construction of the dam.

CHAPTER 2

INSPECTION AND RECORDS EVALUATION

2.1 HYDRAULICS AND STRUCTURES

2.1.1 Spillway

The spillway for Tub Lake is located at the left abutment of Tub Dam. The spillway has been excavated from rock and is best seen in Photos 10 through 12. Approximate dimensions and elevations were determined in the field for use in the calculation of the discharge capacity of the spillway. The average width of the spillway at the bottom is 4 feet, with side slopes averaging 1(V) on 1.5(H). The approximate slope of the spillway downstream from the crest is 7.5%. The spillway discharge capacity was determined by assuming critical depth at the control section and computing water surface profiles upstream into the reservoir, using a Manning's "n" value of 0.040. At the minimum crest elevation of the dam, 9089.6 feet, the discharge capacity of the spillway was calculated to be approximately 55 cfs. The profile of the spillway is shown on Plate 4, and the discharge rating curve is shown on Plate 7. At the time of inspection, a large amount of debris had accumulated at the approach channel inlet (See Photo 10). If this debris would happen to move into the channel during high flows, it could significantly reduce the discharge capacity of the spillway.

2.1.2 Outlet Works

The low-level outlet for Tub Lake Dam is an 18-inch-diameter steel pipe through the embankment (Photo 14). The controls for the pipe are located on the crest of the dam (Photo 13), but are inoperable. At the time of the inspection, with the pool at the natural lake level, there was a small amount of flow coming through the pipe. The inlet for the pipe is covered completely by riprap on the upstream face of the dam, which prevented inspection. While this effectively serves as a trash rack to eliminate debris from entering the pipe, it also inhibits the passage of water through the pipe. It is assumed that the control device, probably a gate valve, is at least partially open. The maximum discharge capacity for the 18-inch outlet was calculated to be about 27 cfs without debris and riprap blocking the entrance. The capacity would be considerably less with the riprap in place. The outlet elevation of the pipe is 9078.1 feet, which is 9.3 feet below the normal pool elevation and 11.5 feet below the minimum crest elevation of the dam. A visual inspection of the pipe was impossible except at the outlet, where some signs of corrosion were noted.

2.1.3 Freeboard

The effective fetch for wind-generated waves is about 1000 feet, and the wave run-up and set-up on the embankment is estimated to be 2.1 feet (Ref. 5). At the normal pool elevation of 9087.4 feet, an approximate

2.2-foot difference exists between the pool elevation and the minimum dam crest elevation. This is considered very marginal in preventing wave overtopping (Ref. 6).

At the time of inspection, the lake had been drained to its natural level, and the pool elevation was approximately 8.5 feet below the normal operating pool level. Under these conditions, the vertical distance was adequate in preventing wave overtopping. Routings indicate that no freeboard exists during the SDF.

2.2 HYDROLOGY, CLIMATOLOGY, AND PHYSIOGRAPHY

2.2.1 Climatology and Physiography

The climate of the area around Tub Lake is continental and characterized by a large diurnal and seasonal temperature range. Extreme variability of wintertime temperatures results from the frequent occurrence of chinook winds, which follow a Pacific maritime air mass invasion.

The summers are characterized by warm days with low humidity and cool nights. Winters are cold and highly variable in severity from year to year and within a given year.

Dillon, in Beaverhead County at an elevation of 5218 feet, is the climatological station nearest the project site. The precipitation and climatological data available from this station are not applicable to the project because of a 3870-foot elevation difference between Tub Lake and the weather station. The average annual precipitation at Tub Lake, as estimated from Soil Conservation Service graphs, is over 40 inches (Ref. 7). At the project site, the expected date of the first freeze is August 13th, and the expected date of the last freeze is July 9th (Ref. 8).

Tub Lake Dam is located on Birch Creek in the Pioneer Mountains and is in the Beaverhead National Forest. The drainage basin above and including Tub Lake has an area of about 0.25 square miles, about 15 acres of which is water surface area. Basin elevations range from the normal pool elevation of 9087.4 feet to 10,400 feet on top of Highboy Mountain. The average ground slope is about 30%. Basin vegetation consists of moderately thick pine and grasses on the lower basin area to sparse pine and rocky surfaces on the upper basin area (see Photos 1 and 2).

2.2.2 Reservoir Storage and Spillway Discharge

The reservoir has a surface area of about 15 acres and a storage of about 172 acre-feet at the spillway crest elevation of 9087.4 feet. Approximately 36 acre-feet of storage is available between the spillway crest and the minimum crest elevation of the dam, 9089.6 feet. The spillway discharge at the minimum dam crest is approximately 55 cfs. The discharge capacity of the facility would increase an additional 27 cfs if the low-level outlet were completely open and free of obstructions.

2.2.3 Estimated Probable Maximum Flood

The probable maximum flood (PMF) is defined as the flood expected from the most severe combination of critical meterologic and hydrologic conditions that are reasonably possible in the region. A storm, the intensity of which approached probable maximum precipitation (PMP) intensity, did occur in parts of Montana in June 1964.

Inspection criteria (Ref. 1) recommend that a small-sized project with a significant downstream hazard potential be capable of handling a spillway desgin flood (SDF) in the range of the 100-year flood to one-half of the PMF. Because of the involved risk for this project, we recommend that the SDF be one-half of the PMF.

A probable maximum precipitation (PMP) storm of 24-hour duration was applied to the basin. The 24-hour, 12-hour, 6-hour and 1-hour PMP depths were estimated from National Weather Service Technical Paper 38 (Ref. 9) to be 15.1 inches, 12.8 inches, 10.4 inches and 6.4 inches, respectively. All 6-hour increments from 0 to 24 hours were arranged in accordance with criteria in Weather Bureau Hydrometeorological Report No. 43 (Ref. 10).

The probable maximum flood was assumed to result from a PMP storm in the late spring, over frozen ground. Therefore, a constant soil loss rate of zero was applied throuhout the 24-hour PMP storm, in accordance with Corps of Engineers recommendations. Thus, the overall configuration of the 24-hour storm is not affected by losses in the soil, and the basin rainfall is equal to the basin runoff for all storm increments. Direct precipitation onto the surface of the lake was also added with no losses.

2.2.4 Flood Routing

For routing the PMF through Tub Lake, the lake level at the beginning of the PMP storm was assumed to be at the spillway crest elevation of 9087.4 feet, which would correspond to the normal pool condition. Since the outlet pipe is blocked and flow is quite restricted, for purposes of this routing, the outlet was assumed to be closed. The total volume of the 24-hour PMF for Tub Lake is approximately 200 acre-feet with a peak flow rate of approximately 2420 cfs. The results of the routing indicate that Tub Lake Dam will handle, through storage and spillway discharge, approximately 28% of the PMF volume before overtopping.

Because the dam is constructed of materials that will probably erode and fail when overtopped by flood waters, the dam was assumed to breach upon overtopping. Spillway and breach discharges from Tub Lake were included in the inflow hydrograph for Pear Lake.

The PMF inflow hydrographs were developed using the SCS dimensionless unit hydrograph. These hydrographs were generated and combined using the HEC-1 (Dam Safety Version) computer program (Ref. 11). The reservoir routing of the PMF was made using the Modified Puls method contained in the HEC-1 program.

2.3 GEOTECHNICAL EVALUATION

2.3.1 Embankment

The 11.5-foot-high earth and rockfill dam is 180 feet long and has a crest width of 17 feet. The upstream slope is 1(V) on 2(H). The downstream slope is a nearly vertical hand-laid rock wall. Borrow for the embankment core appears to have been obtained locally; however, a borrow area was not readily visible. Although the composition of the core is unknown, the material exposed on the crest of the dam is a silty sand matrix, containing gravel and cobbles, which is highly erodible. The upstream portion of the dam is composed of dumped rock, generally ranging in size from 6 inches to 36 inches in diameter. This rock also acts effectively as riprap. No evidence was found of a transition zone between the rock and the silty sand core.

The only vegetated area of the embankment is the crest. The vegetation consists of approximately 50% coverage of native grasses and trees. The trees are pine and fir ranging from 2 to over 15 feet tall (see Photos 5 and 6). In addition to the trees on the crest, there are several dead trees standing on the upstream slope and several more trees growing near the downstream toe. Several rodent holes were noted on the embankment crest.

The presence of sags or bulges on the upstream face could not be determined because of the irregularity of the embankment (see Photo 4). One sag was found on the crest, at the top of the rock wall approximately 20 feet right of the conduit outlet. At this same location, there is a pronounced bulge in the rock wall. In addition a portion of the rock wall near the left abutment (see Photo 5) has fallen down, resulting in some erosion of the embankment core material.

There are two small dikes, both less than 5 feet high, to the left of the dam and spillway (see Photos 7-9 and Plate 5). Both of these embankments have riprapped upstream slopes and are constructed of silty sand similar to that in the dam embankment. The higher of the two, which is closer to the dam, has a nearly vertical rock wall forming the downstream face (see Photo 7). The lower dike has a flat downstream slope (see Photo 9). Rodent holes were noted on both dike embankments.

2.3.2 Foundation Condition, Seepage, and Drainage

The dam is probably founded on silty sand similar to that used in the embankment core. Embankment seepage conditions could not be evaluated due to the low pool level. However, there is vegetative seepage evidence, in the form of leafy weeds and trees, in both the right and left abutment troughs and at the downstream toe of the dam. Although no water was found flowing from any of the suspected seepage areas, higher pool levels may produce sufficient seepage to cause embankment failure by piping.

The dam contains no type of internal drain nor any instrumentation, such as piezometers.

2.3.3 Stability

Because the storage of water is of short duration under present operating conditions, the position of the highest phreatic surface is unknown. Accordingly, a complete evaluation of embankment stability is not possible. However, the dam embankment does not approach present-day design and construction standards or techniques with respect to slopes, filters, and drains. It is our opinion that the stability of the embankment does not conform to inspection guidelines (Ref. 1).

2.4 PROJECT OPERATION AND MAINTENANCE

2.4.1 General

Operation and maintenance of Tub Lake and Dam is the responsibility of the Beaverhead Water Company, with technical assistance provided by the Forest Service. Although there is no formal plan for operation and maintenance of the project, inspection reports dating back to 1959 infer such responsibility.

The reservoir is not currently being used for storage above the natural lake level. However, stream flow which exceeds the capacity of the low-level outlet is temporarily detained. In the past, the reservoir has been used for irrigation storage, being filled in the spring and having irrigation releases throughout the growing season.

Access to the project is very difficult. This limits regular maintenance to those functions which can be performed by hand.

2.4.2 Dam

There is no formal plan for performing maintenance on Tub Lake Dam. Inspection reports and correspondence indicate a general lack of adequate maintenance for many years. In 1969 the Forest Service recommended that the structure be breached. Maintenance is needed on the low-level outlet control works, the low-level inlet, the downstream rock wall, and on the embankment (tree removal and rodent damage repair).

2.4.3 Reservoir

As with the dam, the reservoir has no formal plan for operation and maintenance and has received very little attention for many years. A fairly large amount of debris, mostly dead trees, covers the shore of the reservoir. Debris is also partially blocking the spillway approach channel.

2.4.4 Warning System

There is no formal warning system or plan of action to warn downstream inhabitants or interests in the event of impending dam failure.

CHAPTER 3

FINDINGS AND RECOMMENDATIONS

3.1 FINDINGS

Visual inspection of Tub Lake and Dam, supplemented by analysis of the project in terms of the recommended guidelines' performance standards, resulted in the following findings.

3.1.1 Size, Hazard Classification and Safety Evaluation

In accordance with inspection guidelines, Tub Lake Dam is classified as small in size and, based on our visual inspection and judgment, it has a significant downstream hazard potential. The recommended spillway design flood (SDF) for this project is 50 percent of the PMF. Based on reconnaissance level investigations, the project is incapable of handling 50 percent of the PMF without overtopping and causing the dam to fail. Tub Lake Dam, therefore, does not comply with inspection guidelines with respect to discharge and/or storage capacity.

3.1.2 Embankment Dam

Since this dam has not retained a permanent pool above the natural lake level for some time, no seepage was found. However, evidence of fairly recent seepage was found along nearly the entire length of the embankment. This seepage must occur during times of high runoff when the dam temporarily retains a pool above the elevation of the low-level inlet. With no permanent pool, the embankment would not normally be subjected to steady state seepage conditions. However, the seepage evidence suggests that the embankment may be subjected to a partial pool steady state seepage condition.

The embankment crest is narrow, uneven, and varies by as much as 2 feet in elevation. The lowest point on the crest occurs over the conduit (see Plate 2). This is also near the area where the downstream vertical rock wall has a pronounced bulge and appears unstable.

There is no internal drainage system or piezometers in the dam.

Considering the evidence of seepage, the apparent instability of the downstream face of the dam (rock wall), and experience with similar structures and embankment materials, it is our opinion that the dam does not conform to the recommended guidelines on stability.

3.1.3 Spillway

The earth and rock spillway was found to be in good condition with no erosion damage evident. The absence of a log boom which would protect the upstream end of the channel from debris was the only structural problem noted.

3.1.4 Outlet Works

The 18-inch steel pipe conduit which serves as the low-level outlet appears to be in fair condition. However, only the conduit outlet could be inspected. The control mechanism for the pipe is totally inoperable, and the inlet is completely covered by riprap placed on the face of the dam.

3.1.5 Spillway and Reservoir Capacity

The lake storage and spillway discharge capacities are insufficient to prevent overtopping of the dam during the recommended spillway design flood. This investigation has determined that during the 24-hour PMP storm, the dam can handle approximately 28% of the PMF before overtopping.

3.1.6 Operation and Maintenance

Operation and maintenance are the responsibility of the Beaverhead Water Company, with technical assistance provided by the Forest Service. There is no formal operation and maintenance plan for the project. The project has a history of inadequate maintenance. The growth of trees on the dam, the many rodent holes, the inoperable outlet control works, and the debris partially blocking the spillway approach channel are all indications of the lack of recent maintenance.

There is no formal warning system or plan of action to warn downstream inhabitants in the event of impending dam failure.

3.2 RECOMMENDATIONS

Due to storage between normal pool and dam crest, the present project provides a degree of flood protection to the downstream area. The intent of report recommendations is to maintain or improve project safety, if feasible, without decreasing this existing flood protection.

1. Determine if the dam is still needed or whether it has become an abandoned project. If the project is no longer needed, the dam should be safely removed without delay. If the project is to be restored for its intended purpose, expeditious action should be taken to bring it into conformance with inspection guidelines as recommended below.

2. Immediately develop, implement, and periodically test a downstream notification plan for use in the event of dam distress.

3. Repair or replace the control valve in the outlet conduit and provide a new control wheel. Inspect the entire conduit and repair as required.

4. Uncover the conduit inlet and construct an adequate concrete inlet structure, including a workable trash rack.

5. Remove all trees and root systems from the embankment and adequately backfill and compact the resulting holes.

6. Eliminate the rodent population on the embankment and repair existing rodent damage.

7. Remove debris from reservoir areas to prevent blockage of the spillway and outlet works and construct an adequate log boom.

8. Conduct more-detailed hydrologic and hydraulic routing studies, involving all four of the Beaverhead Water Company's Birch Creek watershed dams, to better determine the downstream hazard and required spillway capcity. Modify the project as studies indicate.

9. Investigate seepage and embankment stability. The study should be performed by a geotechnical engineer experienced in dam design and construction. Modify the embankment as required.

10. Develop and implement a periodic maintenance plan for the dam and appurtenant structures. Because of the remoteness of the project site, the maintenance plan should include frequent condition inspections whenever water is impounded above the natural lake level.

11. Establish a program for periodic, comprehensive, safety inspections at no more than 5-year intervals. These inspections should be performed by engineers qualified in the design, construction, operation, and maintenance of earth dams.

Prior to performing engineering studies and remedial construction, coordinate all work with the U.S. Forest Service and the State of Montana Department of Natural Resources and Conservation to insure compliance with all pertinent laws and regulations.

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1. U. S. Army Corps of Engineers, Office of the Chief of Engineers, Report to the U. S. Congress, National Program of Inspection of Dams, Vol. 1, Appendix D, "Recommended Guidelines for Safety Inspections of Dams", Washington D. C., Department of the Army, May 1975.

2. Howard, K. A., et al, "Preliminary Map of Young Faults in the United States as a Guide to Possible Fault Activity," U. S. Geological Survey, Reston, Virginia, 1978.

3. U. S. Geological Survey, "Earthquake Information Bulletin," Washington D. C., 1973-1978.

4. U. S. Department of Commerce, Earthquake History of the United States, Publication 41-1, Washington D. C.

5. U. S. Army Corps of Engineers, Office of the Chief of Engineers, "Wave Run-up and Wind Set-up on Reservoir Embankments," Engineer Technical Letter No. 1110-2-221.

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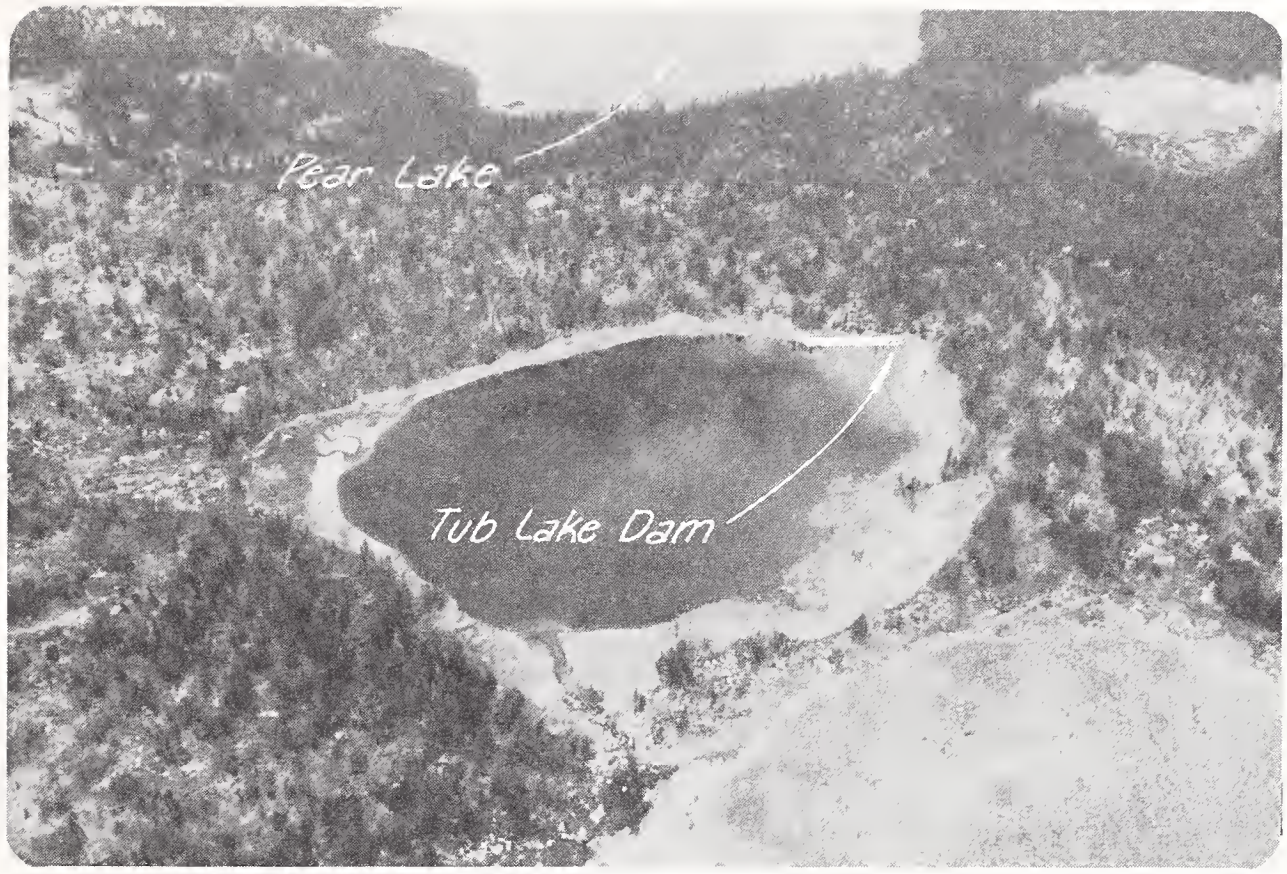


(PHOTO 1) Tub Lake and Dam, Aerial View

(PHOTO 2) Tub Lake Dam

(PHOTO 3) Tub Lake Dam, Upstream Face, Spillway at Left

(PHOTO 4) Upstream Face from Right Abutment
(Inlet under Large Pile of Rocks in Foreground)

(PHOTO 5) Downstream Face from Left Abutment

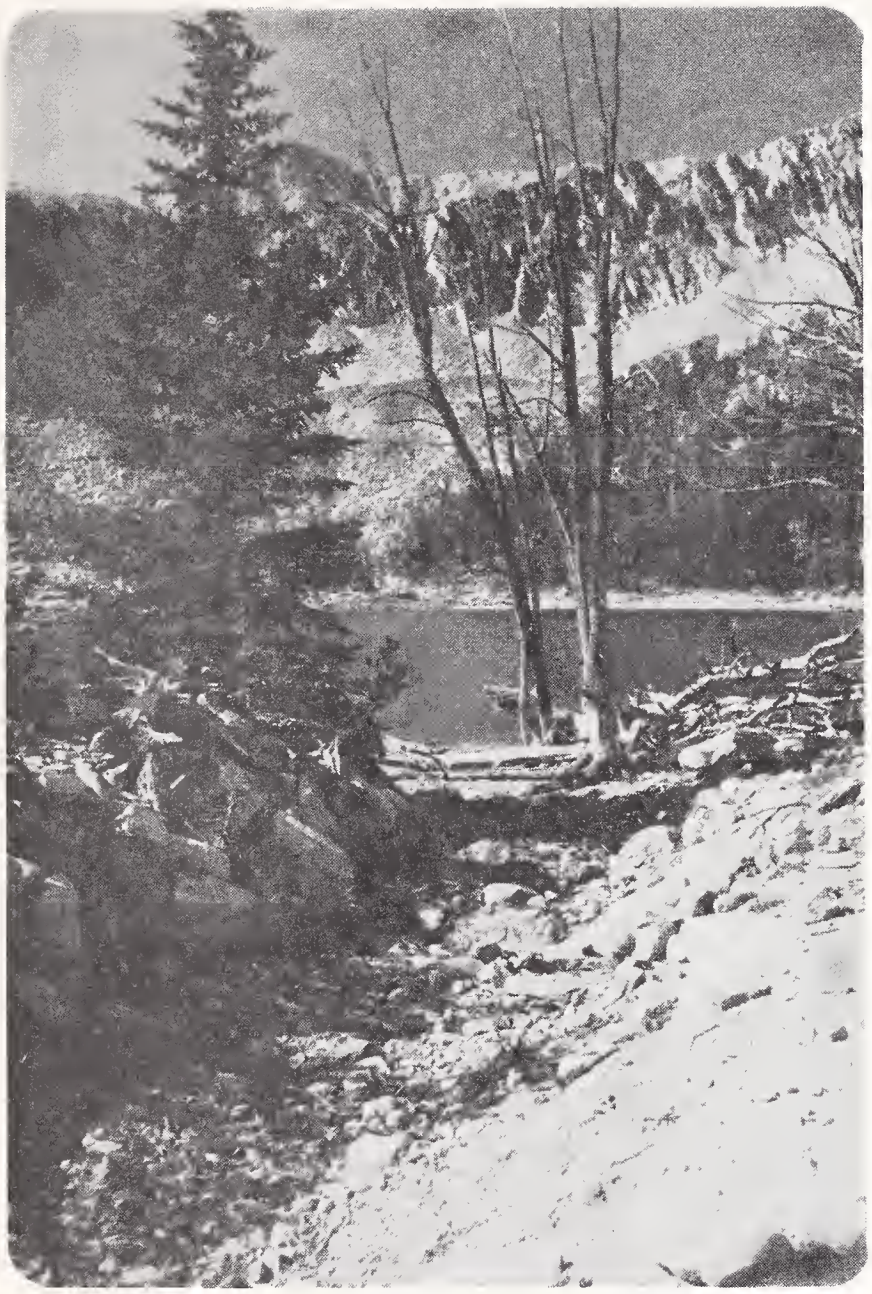
(PHOTO 6) Downstream Face from Right Abutment

(PHOTO 7) Dike 1, Downstream Face

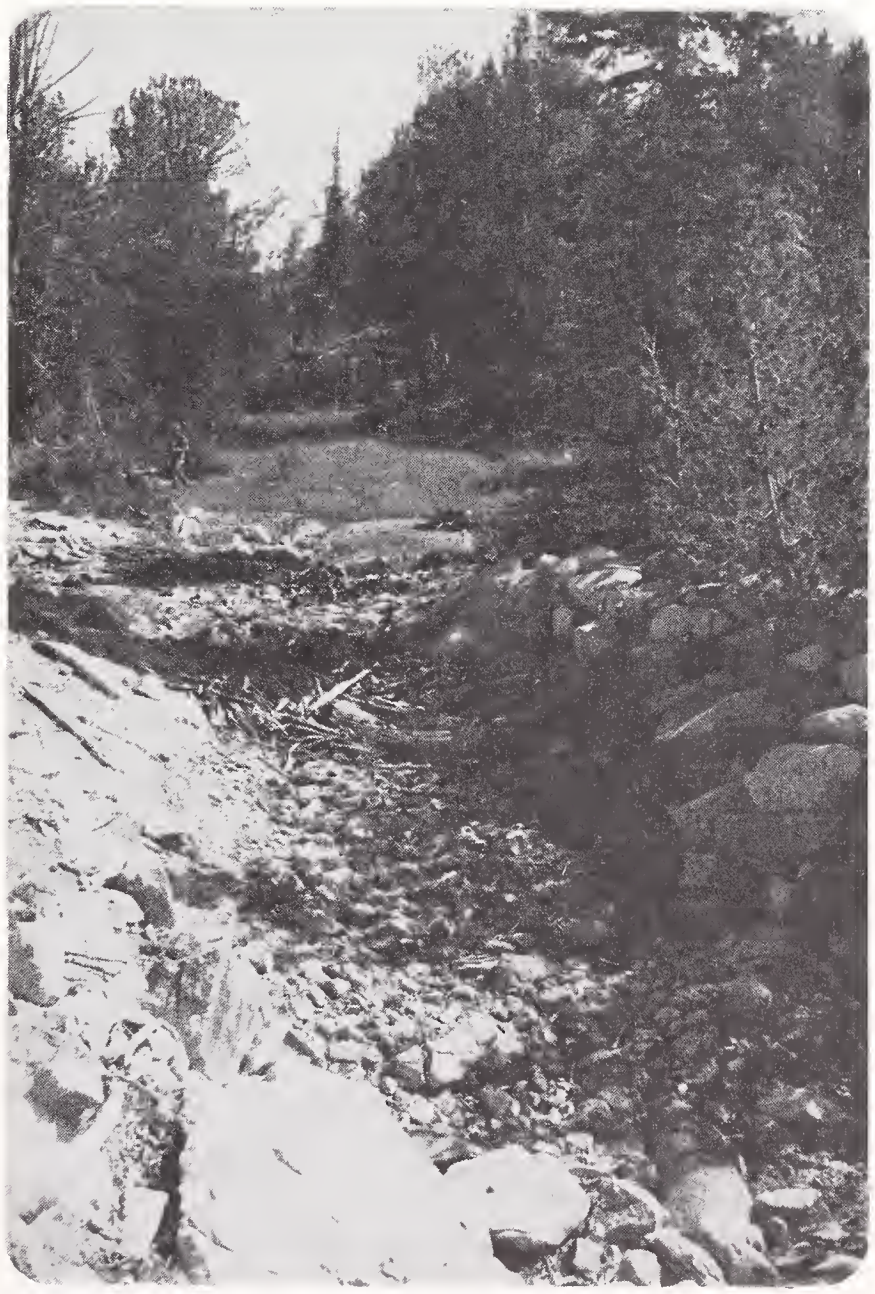
(PHOTO 8) Dike 2, Upstream Face

(PHOTO 9) Dike 2, Downstream Face

(PHOTO 10) Spillway Inlet, Looking Downstream



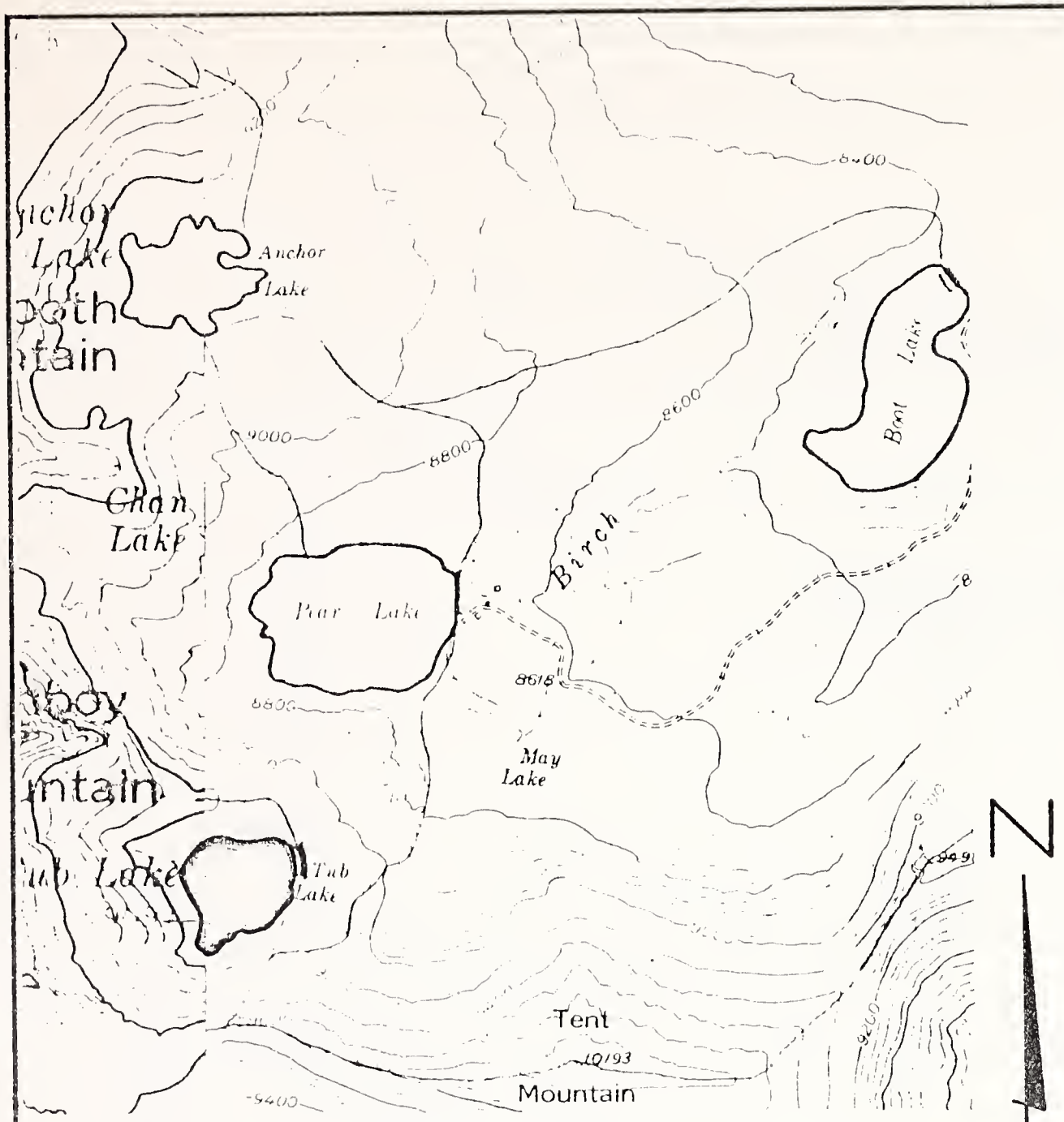
(PHOTO 11) Spillway Approach Channel,
Looking Upstream



(PHOTO 12) Spillway Exit Channel,
Looking Downstream

(PHOTO 13) Low-Level Outlet Control Works

(PHOTO 14) Conduit Outlet



SITE PLAN

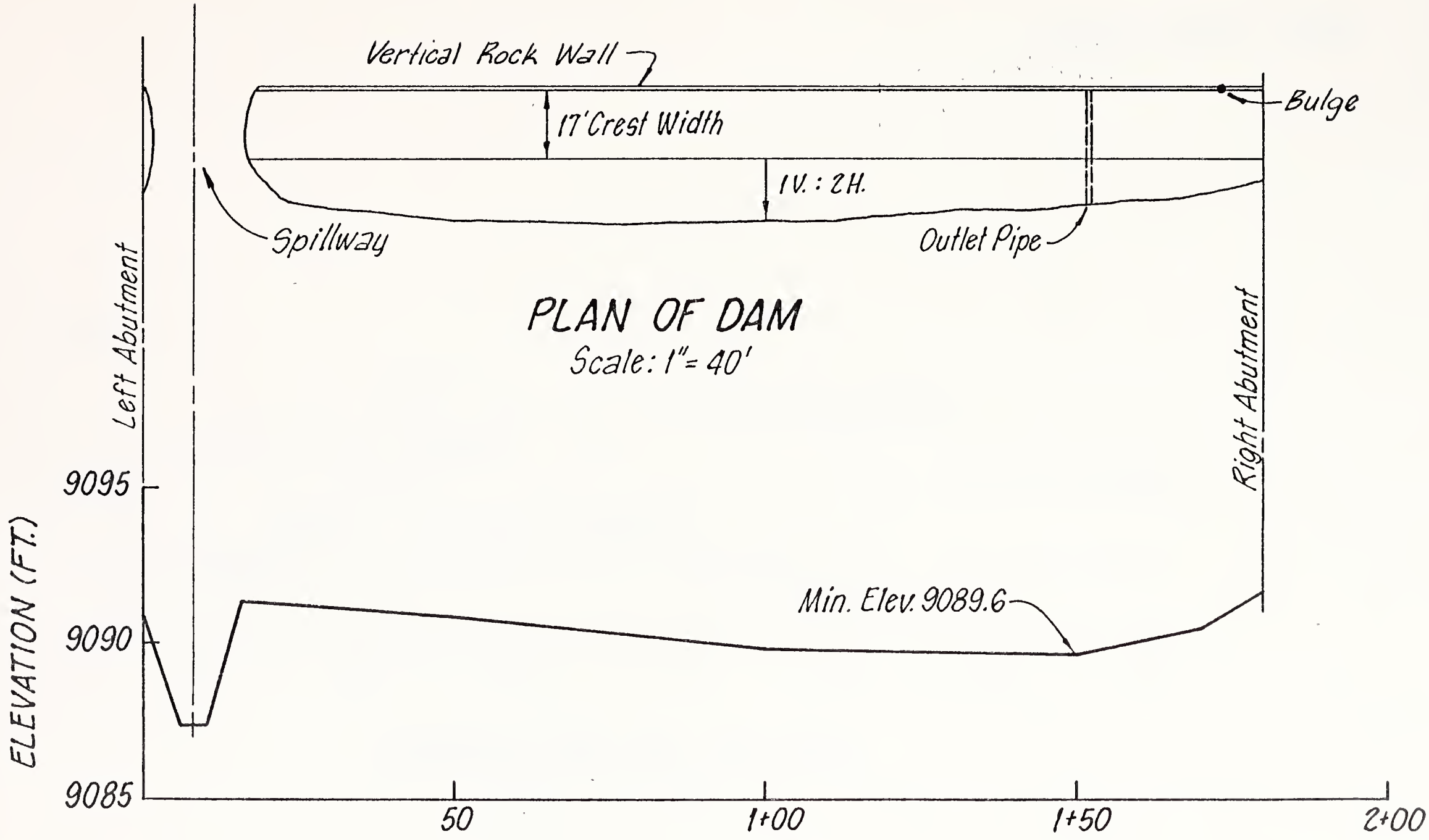
VICINITY MAP

PLATE 1

TUB LAKE DAM (MT-822)

SITE PLAN & VICINITY MAP

TUB LAKE DAM



PLAN OF DAM

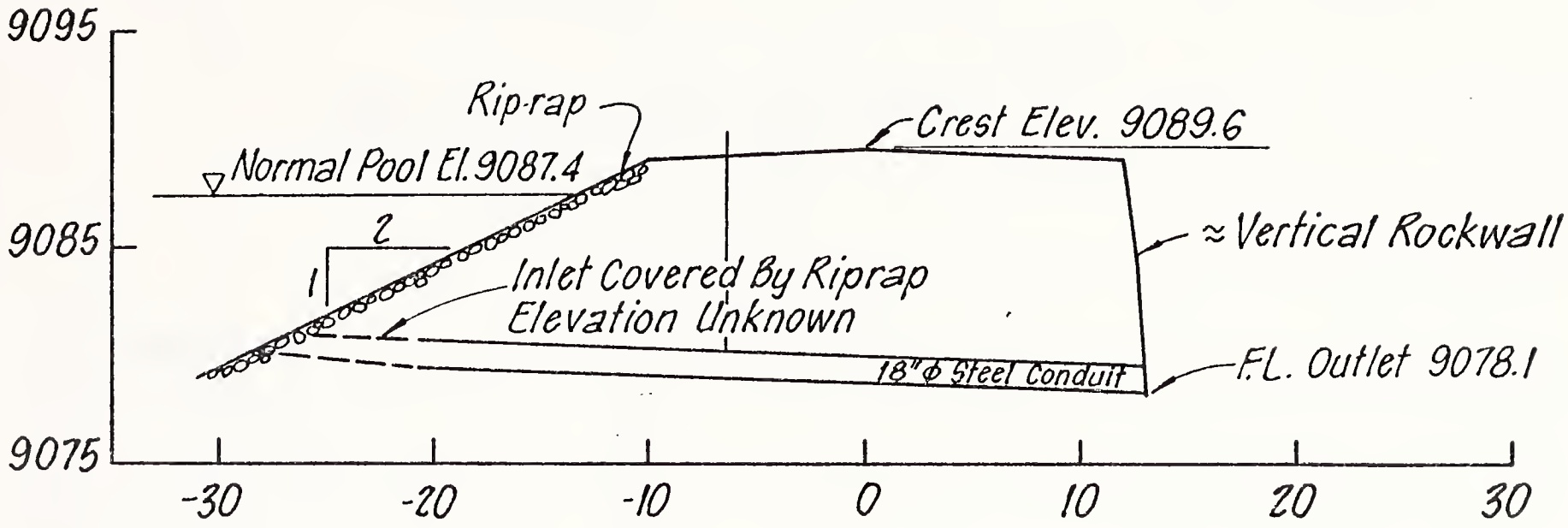
Scale: 1" = 40'

PROFILE OF DAM

Scale: 1" = 25' Horiz.
1" = 5' Vert.

PLATE 2

TUB LAKE DAM

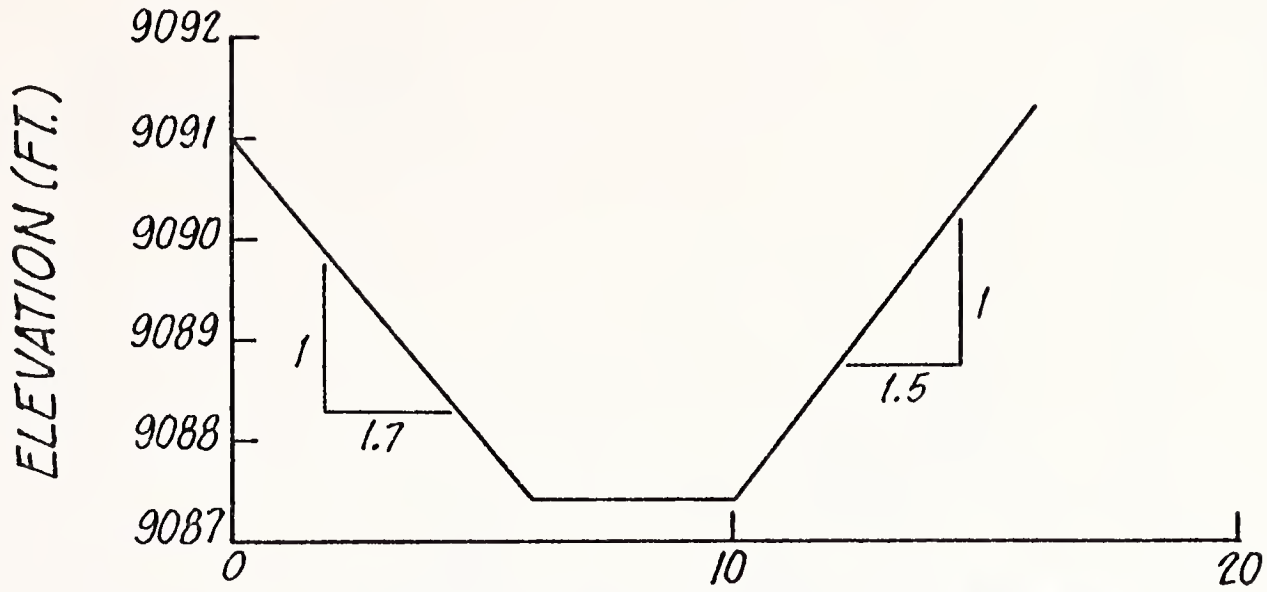


CROSS-SECTION OF DAM

Scale: 1" = 10'

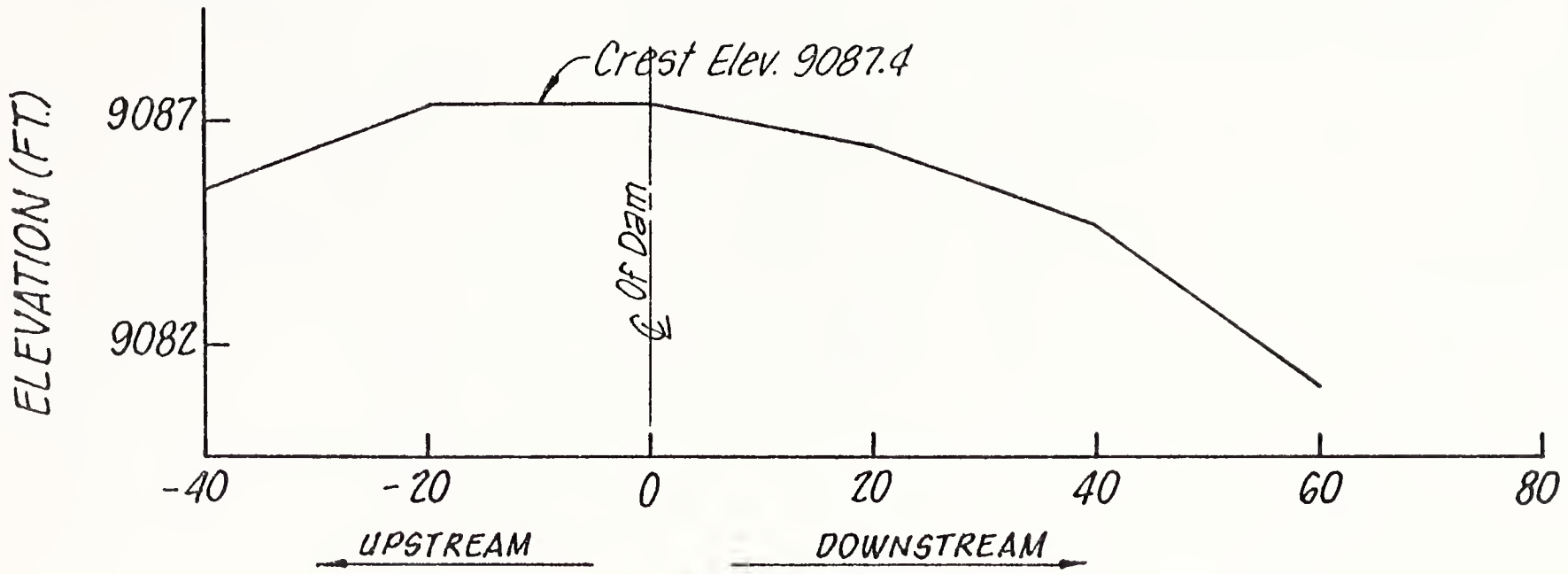
PLATE 3

TUB LAKE DAM



SPILLWAY CROSS-SECTION

Scale: 1" = 5' Horiz.
1" = 2.5' Vert.

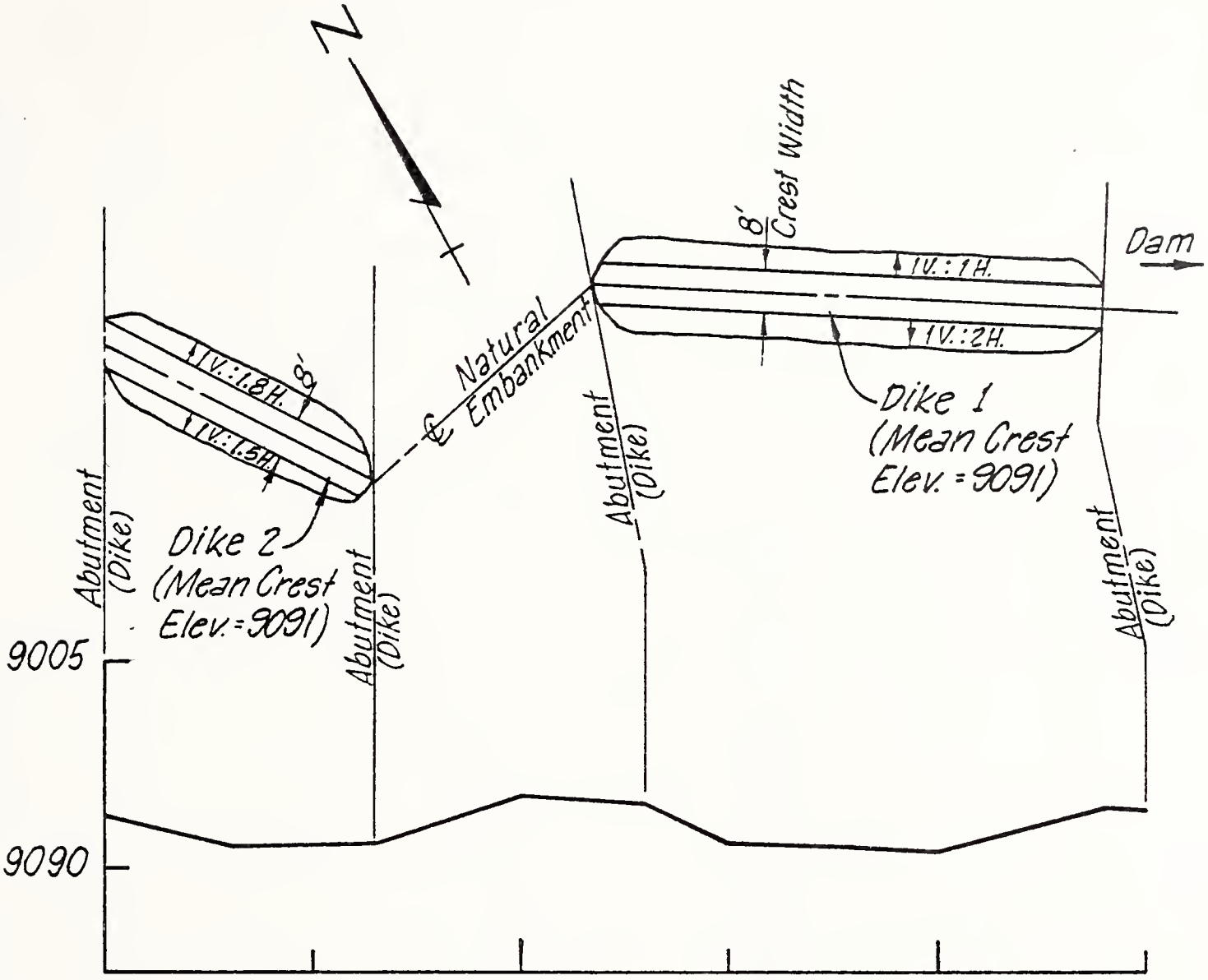


SPILLWAY PROFILE

Scale: 1" = 20' Horiz.
1" = 5' Vert.

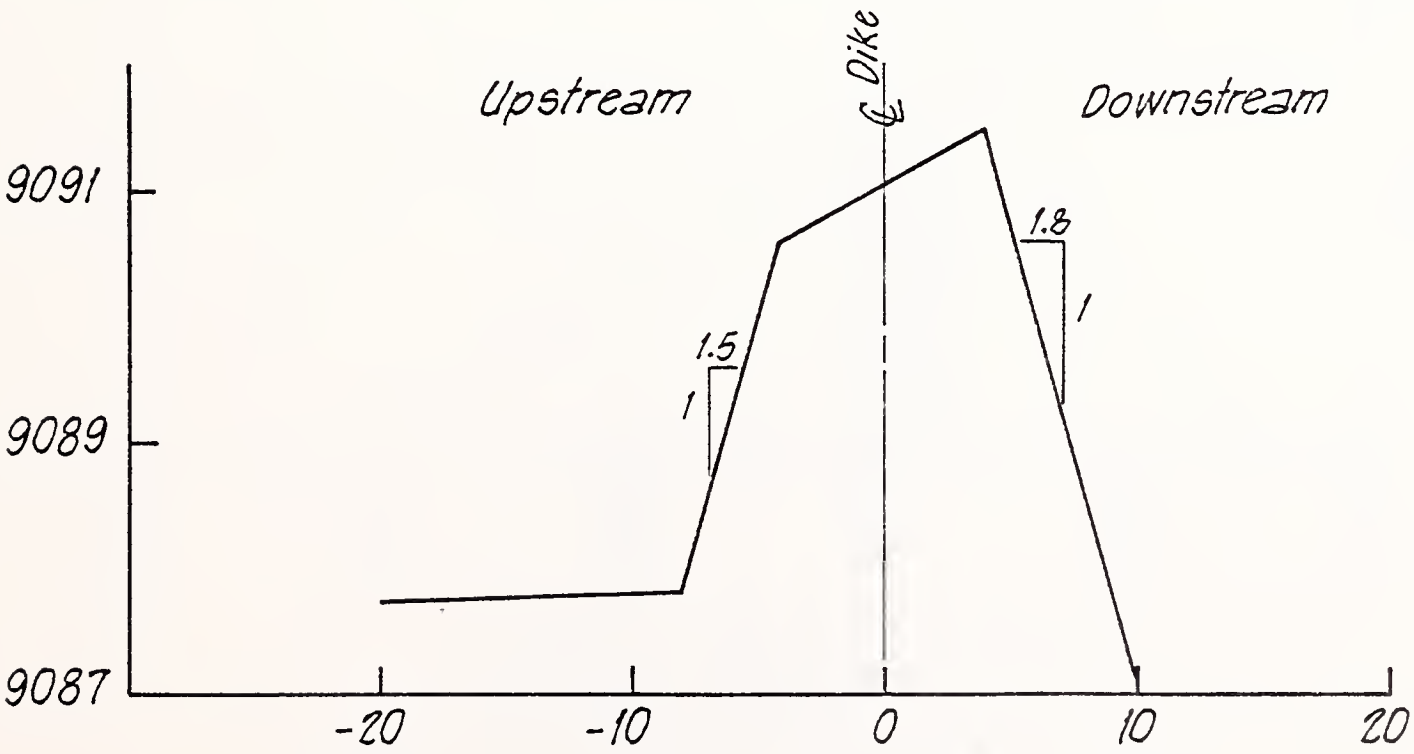
PLATE 4

PLATE 5



PLAN & PROFILE - DIKE

Scale: 1" = 50' Horiz.
1" = 5' Vert.



TYPICAL CROSS-SECTION - DIKE

Scale: 1" = 10' Horiz.
1" = 2' Vert.

TUB LAKE DAM
STAGE-STORAGE-AREA CURVE

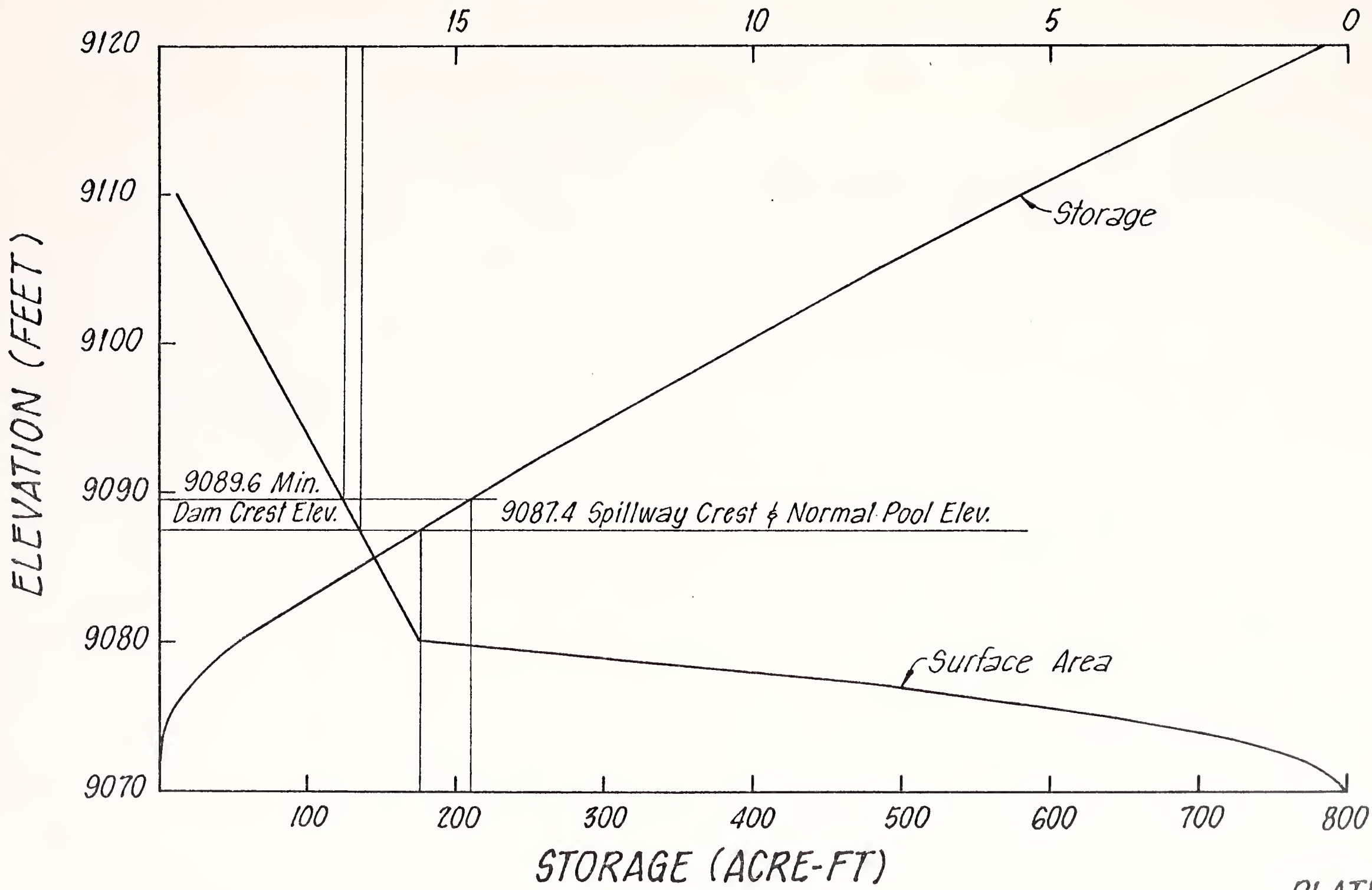


PLATE 6

SPILLWAY DISCHARGE RATING CURVE
TUB LAKE DAM

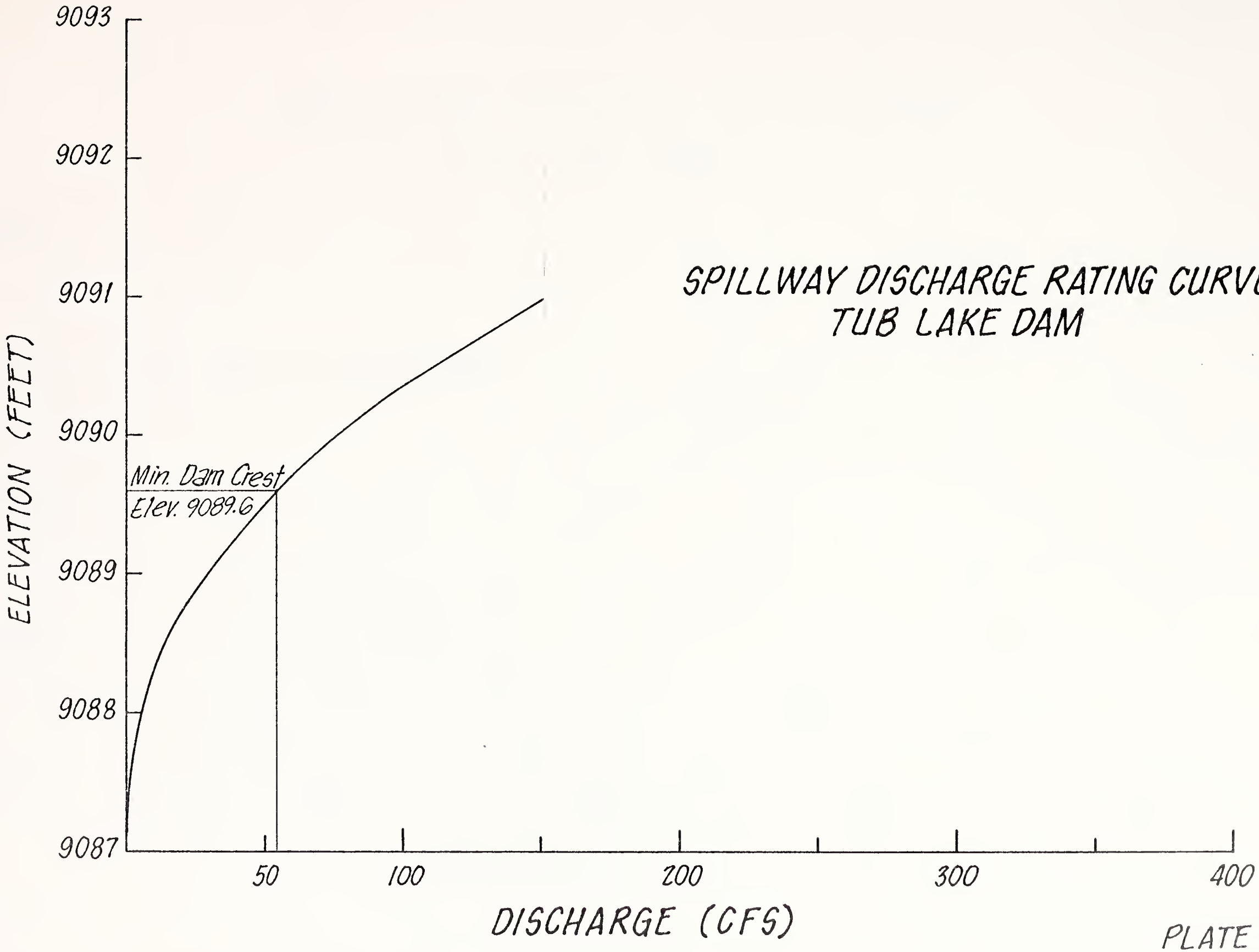


PLATE 7

OUTLET PIPE DISCHARGE RATING CURVE
TUB LAKE DAM

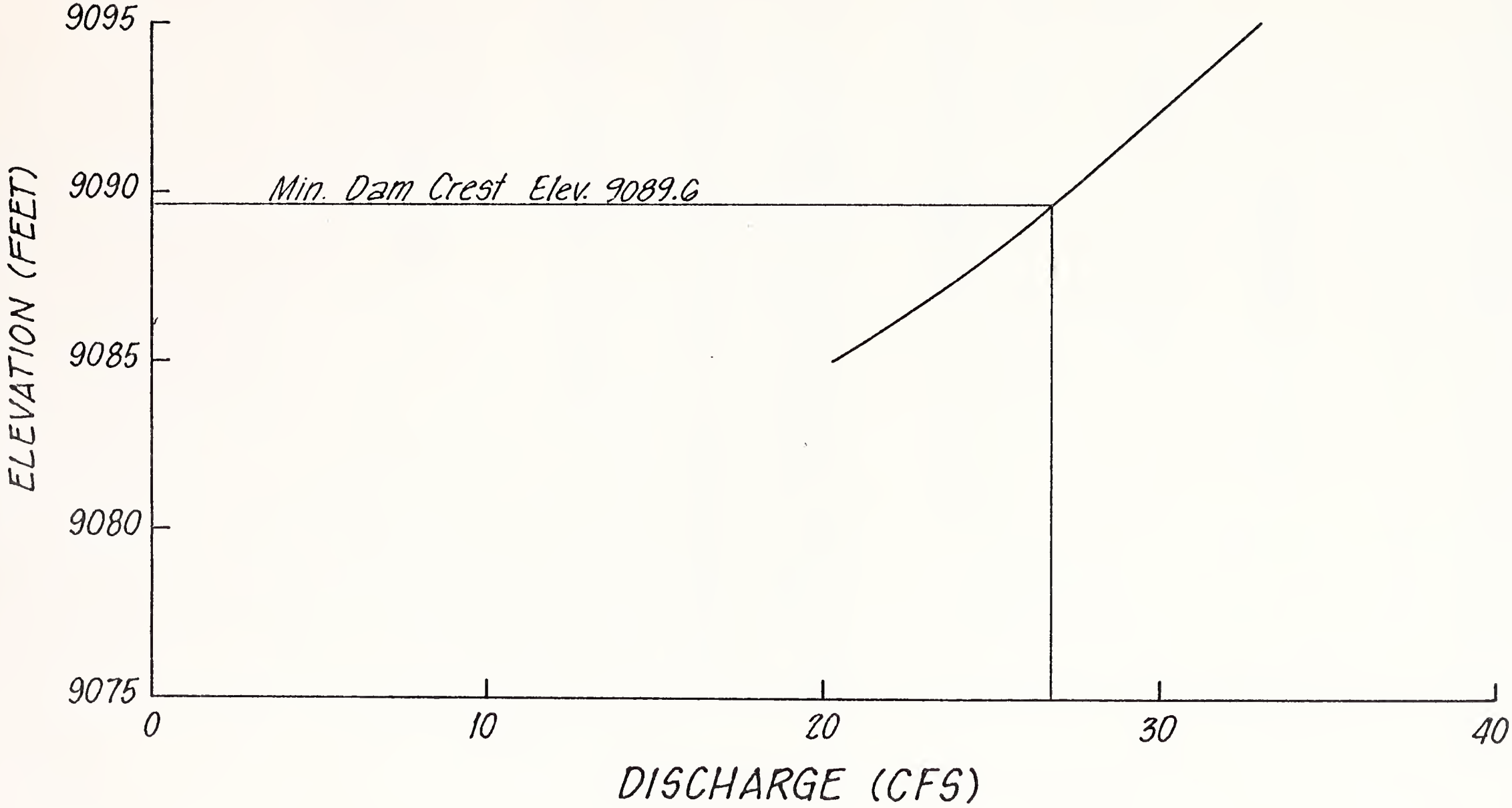


PLATE 8

DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION
WATER RESOURCES DIVISION

THOMAS L. JUDGE, GOVERNOR

32 SOUTH EWING

STATE OF MONTANA

(406) 449-2872

HELENA, MONTANA 59601

December 11, 1980

Department of the Army
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, WA 98124

Attn: Ralph Morrison

Re: Hoskins-Western-Sonderegger, Inc. Dam Safety Report on Tub Lake Dam (MT-822).

Dear Ralph:

We have reviewed the above referenced final draft report. We concur with the findings and recommendations and find that it satisfies the criteria of the Phase I report.

Minor editorial comments have been discussed with your staff, and we understand these will be incorporated in the final report.

Thank you for this opportuntiy to review and comment on the final draft report on Tub Lake Dam.

Sincerely,

Richard L Bondy

Richard L. Bondy, P.E.
Chief, Engineering Bureau
(406) 449-2864

RB/AT/lj

"AN EQUAL OPPORTUNITY EMPLOYER"

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
FEDERAL BUILDING MISSOULA, MONTANA 59801

7530

DEC 1 9 1985

Mr. Sidney Knutson, P.E.
Assistant Chief, Engineering Division
Seattle District, Corps of Engineers
P. O. Box C-3755
Seattle, Washington 98124

Dear Mr. Knutson:

We have reviewed the final draft report for the Phase I inspection of Tub Lake Dam and have the following comments.

We agree a more detailed hydrologic analysis and breach dam routing is needed to better define the hazard this dam and others in the Birch Creek drainage present.

Sincerely,

Beryl Johnston

BERYL JOHNSTON
Acting Director
Engineering

IN REPLY REFER TO:

9100 (941)

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
222 North 32nd Street
P.O. Box 30157
Billings, Montana 59107

DEC 16 1980

Mr. Sidney Knutson, P.E.
Asst. Chief, Engineering Division
Corps of Engineers
P.O. Box C-3755
Seattle, Washington 98124

Dear Mr. Knutson:

Final drafts for Phase I Safety Inspection and Evaluation reports for Tub Lake and Dam Project, MT-822; Pear Lake and Dam Project, MT-820; Anchor Lake and Dam Project, MT-821 (South) and MT 1483 (North); and Boot Lake and Dam Project, MT-823 all located in Beaverhead County, Montana have been reviewed.

We have no additional information or comments to add to the draft reports. The opportunity to review the reports is appreciated.

Sincerely yours,

Henry T. Hammersmark

Henry T. Hammersmark
Chief, Branch of Engineering

BEAVERHEAD WATER COMPANY

Dillon, Montana

6825 Highway 91 North
Route 1
Dillon, Montana 59725

Mr. Sidney Knutson, P.E.
Assistant Chief, Engineering Division
Department of the Army
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, WA 98124

Subject: Tub, Pear and Boot Lake Dams
MT-822, MT-820, MT-823

Dear Mr. Knutson:

Enclosed for your consideration are our review comments on the Phase I Inspection Report on the subject dams. We hope they will be of value to you in preparation of the final report. They were made in consultation with Stensatter Druyvestein and Associates, Consulting Engineers, Missoula, Montana.

We wish to thank you for the opportunity to make comments and look forward to cooperating in efforts to improve water resource development.

Sincerely,

Garth Taylor, President
Beaverhead Water Company

Enclosures

December 1980

REVIEW COMMENTS
by
Beaverhead Water Company, Dillon, Montana
on
Phase I Inspection Report
Tub Lake Dam
Beaverhead County, Montana
MT-822

The Beaverhead Water Company is grateful for this opportunity to comment on the Phase I Inspection Report on the Tub Lake Dam. We are vitally interested in this dam as productivity of lands owned by members of our Company are highly dependent on safe, reliable water storage. The feasibility of rehabilitating this dam will be taken under consideration in the near future. However, to make the rehabilitation of this dam economically feasible, it is important that design criteria be realistic and appropriate for this particular project. It is also important to recognize the additional benefit of providing additional flood control storage.

We recognize our obligations for providing safe water storage consistent with reasonable criteria for the size of structures and hazards involved. However, because the West Bench Irrigation District is heavily obligated to the Federal Government for loans on a new gravity sprinkler system, it has very limited available funds.

The following comments are made for consideration in preparation of the final report.

I Inspection and Safety Criteria

The value of guidelines for implementation of the National Dam Inspection Program is recognized as being very important. We generally agree with provisions in the "Recommended Guidelines for Safety Inspection of Dams" prepared by the Corps of Engineers. But we feel it is equally important to recognize and remember the basis for use of these guidelines. As noted in the Preface to these guidelines, "Safety must be evaluated in the light of peculiarities

and local conditions at a particular dam... The establishment of rigid criteria or standards is not intended." The Preface further states that the "guidelines are intended to be flexible" and contains the following paragraph:

> "Conditions found during the investigation which do not meet guideline recommendations should be assessed by the investigator as to their import from the standpoint of the involved degree of risk. Many deviations will not compromise project safety and the investigator is expected to identify them in this manner if that is the case. Others will involve various degrees of risk, the proper evaluation of which will afford a basis for priority of subsequent attention and possible remedial action."

Therefore, as will be pointed out in more specific comments, we think that evaluations and recommendations for each dam should be consistent with the particular circumstances.

II Inspection

The primary purpose of Phase I investigations is to identify those dams which may pose hazards to human life or property. This is good. However, we are not pleased with far reaching safety evaluations and costly recommendations based on a brief site visit. We think that if potentially serious conditions exist, or if costly recommendations are made, then they should be made based on a more thorough investigation and analysis by experienced engineering personnel. In this case, they should have a background in high mountain dam construction and hydrology. This is consistent with the intended use of the guidelines.

III Existing Dam

It is important in any investigation and evaluation of a dam to keep in mind the difference between new design criteria and evaluation criteria for an existing structure. In some aspects they are similar or even identical, but in others they are different. Here again experience is important as many other dams in Western Montana are constructed of similar or identical soils with rock facing slopes. As another example, the need for and value of installing and monitoring piezometers is highly questionable.

IV Classification

The hazard potential classification of "significant" is based on "...approximately 2 inhabitable structures located about 10 miles downstream from Boot Lake ..." We question the accuracy of this rating and believe it should be "low". Was a flood routing done past these structures? Were cross sections and elevations taken near these structures to determine if loss of life would be expected if they were occupied? Are they in fact used or inhabited a significant amount of time?

This is highly important as the degree of risk affects spillway capacities, freeboards and other features on this and other dams.

V Hydrology

In general, we believe that the hydrologic analyses performed under this study are inadequate to serve as a basis for any significant changes in the dams, spillways or hazard ratings. We agree that not enough is known about high mountain basin hydrology to accurately predict exact storm or snowmelt runoff. But we don't agree that an ultra conservative approach should be

followed because of this lack of knowledge or data. To begin with, we think a Q_{100} evaluation flow is much more realistic for a low hazard structure such as this. The guidelines recommend Q_{50} to Q_{100}.

With regard to a Probable Maximum Flood (PMF) analysis, to go from Probable Maximum Precipitation (PMP) to PMF with no infiltration or other deductions certainly is conservative, but not necessarily realistic for this situation. Also, the basis for using a 24-hour PMP is unknown and unsupported.

VI Flood Warning System

Considering the size and remote, unattended location of these dams, and the determination that only "approximately 2" inhabitable structures would be directly affected by a dam failure, the recommendation to "Immediately develop, implement, and periodically test an emergency warning system..." seems totally inappropriate. If there was any advance notice, it would seem that the best plan would be to directly notify anyone living along the stream in person or through the sheriff's department.

VII Seismicity

Based on the Seismic Zone Map of Contiguous States, Fig. 1 Corps Guidelines, this dam is approximately on the boundary between Zones 2 and 3. Based on this and other geologic and historical data, we question the accuracy of calling the Pioneer Mountains a "highly seismically active area". We wonder what wording would be used for areas in southern California.

VIII Maintenance and Repair Recommendations

These are generally acceptable except for items previously covered. Another exception would be the removal of all root systems from bushes and tress which we don't think is necessary. In addition, we do not concur with the need for "...frequent condition inspections whenever water is impounded above the natural lake level" .

The remoteness of the site make inspections, maintenance and repairs difficult and expensive, but we agree that improvements can be made in these areas.

Beaverhead Water Company

Garth Taylor, President

DEPARTMENT OF THE ARMY
SEATTLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX C-3755
SEATTLE, WASHINGTON 98124

NPSEN-FM

26 January 1981

Garth Taylor, President
Beaverhead Water Company
6825 Highway 91 North
Route 1
Dillon, Montana 59725

Dear Mr. Taylor:

Thank you for providing comments on the draft dam safety reports for your company's dams: Anchor Lake Dams, MT-821 and MT-1493; Tub Lake Dam, MT-822; Boot Lake Dam, MT-823; and Pear Lake Dam, MT-820. Your comments have been considered in preparation of the final reports and all your comments will be appended to the final reports.

I am gratified that you and your company have such a keen interest in dam safety and I share your view about properly maintaining the structures without having to do unnecessary engineering studies or remedial work.

The inspections were conducted by experienced engineers who used the inspection guidelines developed by the Corps of Engineers in consultation with states and other engineering organizations, both within and outside the Government. The guidelines are used as a screening tool to determine if existing dams are in need of further study and/or remedy. The Corps of Engineers has no enforcement authority in implementing report recommendations.

The inspecting engineers used judgement in arriving at the downstream hazard classification for your dams. Because the downstream hazard potential is so important to what a dam's capability must be in controlling floods, we have recommended that additional basin hydraulic and hydrology studies be undertaken by you to better define the interrelationships of your dams and the potential hazards of dam failure and to base each project's needed flood handling capability on that more in-depth study. This study should form the basis for all safety-related activities at each site. Both the United States Forest Service and the Montana Department of Natural Resources and Conservation's Engineering Bureau concur in this approach.

NPSEN-FM
Garth Taylor, President

Your concern about our recommendations on downstream warning plans is well taken. Our intent here is to have some workable plan to promptly notify the downstream residents and interests in case of dam distress. We are not advocating any alarm system such as sirens, etc. Your idea of having the affected parties notified by the Sheriff or someone designated for that purpose is the kind of plan we meant, but it should be a formal written and coordinated plan showing who has responsibility.

Sincerely yours,

Sidney Knutson